

1        **DENTAL PROSTHESIS MANUFACTURING PROCESS, DENTAL**  
2        **PROSTHESIS PATTERN & DENTAL PROSTHESIS MADE THEREBY**

3  
4                    **BACKGROUND OF THE INVENTION**

5  
6            Computer technology has advanced to the point where a dental  
7        prosthesis may be milled from a solid block of material based on three-  
8        dimensional digital data corresponding to a proposed shape of the  
9        dental prosthesis. The dentist first makes an impression of a patient's  
10      existing dentition. Typically, this includes nearby surfaces where the  
11      prosthesis is to be located in the patient's mouth. This is accomplished  
12      by the dentist first drilling away any unwanted dental tooth structure  
13      and then having the patient bite into an impression material that forms  
14      a negative impression of the patient's dentition, including the tooth  
15      structure to which the dental prosthesis is to be attached. This negative  
16      impression is then filled with dental die stone to make a model of the  
17      tooth structure to which the dental prosthesis is to be attached and  
18      adjacent teeth, particularly the teeth immediately above and to the  
19      sides of the tooth structure to which the dental prosthesis is to be  
20      attached. This model of the patient's dentition captures an impression of  
21      the occlusion surfaces between upper and lower aligned teeth and the  
22      configuration of the tooth structure to which the dental prosthesis is to  
23      be attached.

24           The computer aided design equipment used to make a dental  
25        prosthesis has <sup>d</sup>(an) scanner that is used to scan the surfaces of the model.  
26        Scanning may be accomplished either with optical techniques using  
27        laser or non-laser light or tactile techniques where a probe physically  
28        contacts the tooth's surface. The computer aided design equipment  
29        converts the model's surfaces into three-dimensional digital data  
30        corresponding to the physical shape of the model. This original data

1 collected during scanning is then used to create an image of the  
2 proposed shape for the prosthesis on a screen of a computer monitor.  
3 The computer aided design equipment is programmed to allow the user,  
4 with the aid of a mouse and employing conventional point and click  
5 techniques, to change the shape of the image. The original image  
6 displayed on the monitor screen needs to be adjusted to modify the  
7 original image to correspond to the ultimate shape of the dental  
8 prosthesis.

9 Because the data originally collected during scanning isn't precise  
10 enough to make the dental prosthesis directly based on this data, the  
11 user can and does make adjustments to the data originally provided by  
12 the scanner so that the dental prosthesis, at least in theory, fits properly  
13 into the patient's mouth. After making such adjustments to the data  
14 collected by the scanner, the adjusted three-dimensional digital data is  
15 then forwarded to an automatic milling machine which then mills away  
16 the unwanted material from a block to form the dental prosthesis.  
17 Typically, the block of material is a ceramic, titanium, or composite  
18 plastic material. One of the perceived advantages of this technique is  
19 the elimination of conventional investment casting of a wax pattern of  
20 the dental prosthesis, which has conventionally been used to make a  
21 dental prosthesis.

22 Although this computer aided design equipment proposes to  
23 eliminate conventional investment casting, it suffers from a number of  
24 drawbacks that prevent greater utilization of this technology. First, it is  
25 impractical to make dental prosthesis from such precious metals as gold  
26 and platinum using this technology because so much of the precious  
27 metal is lost during the milling process. Second, the adjustments made  
28 to the image based on the original data collected during scanning  
29 usually fail to create a dental prosthesis that properly fits into the  
30 patient's mouth. The inaccuracies in the shape of the dental prosthesis

1 so produced using this technology are particularly acute along the  
2 marginal edges of the prosthesis adjacent the margins where the treated  
3 (drilled) tooth surfaces of an individual tooth are contiguous with the  
4 untreated (undrilled) tooth surfaces of this individual tooth.

## 5 6 SUMMARY OF THE INVENTION

7  
8 This invention overcomes the drawbacks associated with the  
9 computer aided design technology that eliminates investment casting of  
10 a dental prosthesis and directly mills the prosthesis from a block of  
11 material. It has several features, no single one of which is solely  
12 responsible for its desirable attributes. Without limiting the scope of  
13 this invention as expressed by the claims that follow, its more  
14 prominent features will now be discussed briefly. After considering this  
15 discussion, and particularly after reading the section entitled,  
16 "DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT," one will  
17 understand how the features of this invention provide its benefits,  
18 which include, but are not limited to,

19 (1) usage of precious metal in making a dental prosthesis with  
20 minimum waste of such metal,

21 (2) improved accuracy of the marginal edges of the dental  
22 prosthesis positioned along the margins of a tooth structure, and

23 (3) reduction of time to make a dental prosthesis using  
24 conventional investment casting techniques.

25 The invention includes a method of manufacturing a pattern of a  
26 dental prosthesis from a wax material, a method of manufacturing a  
27 dental prosthesis itself using this pattern, the dental prosthesis itself,  
28 and the pattern used in the manufacture of the dental prosthesis. As  
29 used herein, a dental prosthesis includes wax-ups (a term used in the  
30 industry) of articulated jaws. These wax-ups constitute an entire array

1 of the teeth in an individual patient and they are used for diagnostic  
2 purposes. As used herein, "wax material" includes waxes,  
3 thermoplastics, combinations of wax and thermoplastic, or other  
4 ablative materials that are commonly used in the lost wax process.

5 The first step of the method of this invention is to form a model of  
6 a patient's dentition. This model includes surfaces corresponding to the  
7 dental structure nearby the location that the dental prosthesis is to be  
8 placed in the mouth of a patient.

9 The second step is to create three dimensional digital data  
10 corresponding to these surfaces, and based at least in part on this data,  
11 to create three dimensional digital data substantially corresponding to  
12 the dental prosthesis to be manufactured. Typically this is  
13 accomplished using a scanner to scan the surfaces of the model to collect  
14 three dimensional digital data corresponding to these surfaces. A  
15 monitor screen of computer aided design equipment displays an image  
16 of a proposed dental prosthesis based, at least in part, on the collected  
17 three dimensional digital data corresponding to the surfaces of the  
18 model. With the aid of the computer aided design equipment, the image  
19 is modified so that the modified image displayed on the monitor screen  
20 substantially corresponds to the dental prosthesis to be manufactured.

21 The third step is to transmit the three dimensional digital data of  
22 the dental prosthesis to be manufactured to automated prototyping  
23 equipment. Using the automated prototyping equipment, a wax pattern  
24 of the dental prosthesis is made from a wax material. This pattern is  
25 then used in the lost wax investment casting process to manufacture the  
26 dental prosthesis.

27 In accordance with this invention, the pattern has marginal edges  
28 that are at least 3/4 of a millimeter from margins of an individual tooth  
29 structure to which the dental prosthesis is to be attached. These set  
30 back marginal edges of the pattern are manually adjusted to

1 compensate for the specific configuration of the individual tooth  
2 structure by adding wax material to these set back marginal edges. This  
3 insures that the inaccuracies ordinarily occurring using computer aided  
4 design and milling equipment are avoided.

## 5 6 DESCRIPTION OF THE DRAWING

7  
8 The preferred embodiment of this invention, illustrating all its  
9 features, will now be discussed in detail. This embodiment depicts the  
10 novel and non-obvious method of manufacturing a pattern of a dental  
11 prosthesis from a thermoplastic material, and pattern and dental  
12 prosthesis made by this method, as shown in the accompanying  
13 drawing, which is for illustrative purposes only. This drawing includes  
14 the following figures (Figs.), with like numerals indicating like parts:

15  
16 Fig. 1 is a perspective view of the upper jaw portion of a model for  
17 a patient's dentition.

18 Fig. 1A is an enlarged fragmentary view of part of the upper jaw  
19 portion of the model for a patient's dentition shown in Fig. 1, depicting a  
20 stump on which a crown type dental prosthesis is to be attached.

21 Fig. 2 is the monitor screen of computer aided design equipment  
22 programmed to create images of different shaped dental prosthesis.

23 Fig. 3 is the monitor screen of computer aided design equipment  
24 displaying how different portions of an image of a dental prosthesis  
25 may be modified.

26 Fig. 4 is another view of the monitor screen showing a dental  
27 prosthesis mounted to a tooth structure.

28 Fig. 5 is a schematic diagram of computer aided design equipment  
29 used in the method of this invention.

1 Fig. 6 is a side elevational view of a treated tooth structure to  
2 which a crown type dental prosthesis is to be attached.

3 Fig. 7 is a schematic diagram of computer aided design equipment  
4 connected to automated prototyping equipment that makes a pattern  
5 (referred to herein as wax pattern) of the dental prosthesis from wax  
6 material.

7 Fig. 8 is a schematic cross-sectional view showing a wax pattern of  
8 a crown type dental prosthesis positioned in a casting ring used in  
9 investment casting.

### 11 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

12  
13 In accordance with conventional techniques, a model of a patient's  
14 dentition is made. The upper jaw portion 10 of such a model is shown  
15 in Fig. 1. A lower jaw portion of this model is also used to collect tooth  
16 surface data, but is not shown. For purposes of illustration as shown in  
17 Fig. 6, an actual stump 32 to which a crown type 50a dental prosthesis  
18 is to be attached includes a drilled away portion 32a and an  
19 undisturbed portion 32b next to the patient's gum 34. Where the  
20 contiguous borders of the portions 32a and 32b meet, as defined by the  
21 line 38, a margin is formed. The jaw portion 10 includes a replicate 32a  
22 of the stump 32 to which the crown type dental prosthesis 50a is to be  
23 attached.

24 As shown in Fig. 6, computer aided design equipment 19 creates  
25 an image of a dental prosthesis based on data collected from the model  
26 of the patient's dentition. As illustrated in Fig. 7, computer aided design  
27 equipment sold under the trademark LabQraft™ by Dentalmatic  
28 Technologies, Inc. of St. Laurent, Quebec, Canada is modified in  
29 accordance with this invention to eliminate milling apparatus connected  
30 to an output 19a. In accordance with this invention, this output 19a is

1 connected to automated prototyping equipment 23. Other similar type  
2 equipment such as sold by Decim AB of Skelleftea, Sweden, may also be  
3 modified by eliminating the milling equipment and used in accordance  
4 with this invention. Suitable automated prototyping equipment 23 is  
5 sold under the trademark ModelMaker II™ by Sanders Prototype, Inc. of  
6 Merrimack, New Hampshire.

7 The equipment 19 includes an optical scanner 20 that scans the  
8 surfaces of the model of a patient's dentition by directing a beam of  
9 light from a source 17 at the model's surfaces, for example, at the tooth  
10 surfaces of the upper jaw portion 10. The reflected light represents  
11 information corresponding to the contours of these surfaces. This  
12 information is collected by a sensor 15 and then stored in the memory  
13 22 of a computer 24 as three dimensional digital data. Various images  
14 of a dental prosthesis are displayed on a screen 18 of a monitor 30  
15 connected to an output 32 of the computer 24 based on the data  
16 originally collected by the scanner 20. These images, and the  
17 corresponding data creating these images, are modified by the user  
18 using conventional input devices such as a mouse 26 and keyboard 28  
19 to interact with, and modify, the originally collected three dimensional  
20 digital data.

21 The numeral 12 is an image displayed on the screen 18  
22 corresponding to the actual tooth structure, that is, the stump 32 (Fig. 6)  
23 that has been prepared by a dentist for a dental prosthesis. The image  
24 12 is created upon optically scanning the surface of the replicate 32a of  
25 the stump 32 and manipulating the collected information of the surface  
26 contours, creating the image 12 in accordance with a program 24a that  
27 controls processing of the data by the computer 24. As depicted in Fig.  
28 3 and 4, an image 14 of the crown 50a to be attached to the stump 32 is  
29 displayed on the monitor's screen 18. In this example, an image 40 of  
30 the surface of an upper tooth immediately above and facing the stump

32 and an image 42 of the surface of the upper adjacent tooth are also displayed on the monitor's screen 18. Through the use of the mouse 26 and keyboard 28 the user can change parameters such as die spacer, minimum thickness of the prosthesis, contact points, grooves, cusp overlays and marginal ridges.

In accordance with this invention, the automated prototyping equipment 23 makes a wax pattern 50 (Figs. 7 and 8) from wax material. This wax pattern 50 is based on the data collected during optical scanning. Typically, the pattern 50 is formed by a series of wax layers laid one upon another until the desired overall shape is completed. The wax pattern 50 formed by the method of this invention is at least 3/4 millimeters from the margin line 38a corresponding to the actual margin line 38 as determined when the pattern 50 is seated by a dental technician on the replicate 32a of a stump 32. In other words, when the user is creating on the monitor screen 18 an image 14 of the crown 50a, the edges 14a of this image 14 are at least 3/4 of a millimeter from an image 38a of the margin line displayed on the screen 18. Consequently, the wax pattern 50 has marginal edges 51 that are displaced at least 3/4 millimeters from the margin line 38a on the replicate 32a that correspond to the actual margin line 38. In accordance with this invention, the edges 51 of the pattern 50 are then manually adjusted to compensate for the specific configuration of the stump 32 by adding a wax material to these edges. This avoids the inaccuracies associated with attempting to make a dental prosthesis that fits properly based solely on computer manipulation of data and then milling the prosthesis from a block of material as dictated by this data.

The wax pattern 50 produced by the automated prototyping equipment 23 is used in the conventional investment casting process to make the crown type dental prosthesis 50a. As shown in Fig. 8, the wax pattern 50 is attached to a sprue 60 made of wax material. This sprue



1 60 is mounted to a raised conical portion of a rubber base 62 and a  
2 metal ring 64 lined with a sheet 68 of ceramic fiber paper is seated on  
3 the base. Preferably, a wax rod 70 extends from a side portion of the  
4 pattern 50 to the base 62. The hollow interior 64a of the ring 64 and  
5 base 62 is then filled with the investment material, for example, a  
6 plaster, that is allowed to dry. After drying the assembly of the base  
7 62, ring 64 and mounted wax pattern 50 is inverted and the base  
8 removed. The sprue 60 and wax pattern 50 are next removed by  
9 burning them away so that the casting is formed with a hollow cavity  
10 (not shown) into which molten metal is poured to form the crown 50a.

## 11 12 SCOPE OF THE INVENTION

13  
14 The above presents a description of the best mode contemplated  
15 of carrying out the present invention, and of the manner and process of  
16 making and using it, in such full, clear, concise, and exact terms as to  
17 enable any person skilled in the art to which it pertains to make and  
18 use this invention. This invention is, however, susceptible to  
19 modifications and alternate constructions from that discussed above  
20 which are fully equivalent. For example, although only crowns have  
21 been illustrated, other dental prosthesis such as, for example, bridges  
22 and inlays can be made using this invention. Moreover, this method  
23 may also be used to make wax-ups of articulated jaws used for  
24 diagnostic purposes. Consequently, it is not the intention to limit this  
25 invention to the particular embodiment disclosed. On the contrary, the  
26 intention is to cover all modifications and alternate constructions coming  
27 within the spirit and scope of the invention as generally expressed by  
28 the following claims, which particularly point out and distinctly claim  
29 the subject matter of the invention: